Linear Programming and Network Optimization

ESI 6417

Class Periods: MWF Period 9 (4:05 pm – 4:55 pm)

Location: WEIM 1076

Academic Term: Spring 2023

Instructor:
Name: Yu Yang
Email Address: yu.yang@ise.ufl.edu.
Office Phone Number: (352) 294-7727
Office Hours: WF 3 pm – 4 pm, Weil 401C; Extra time by appointment through e-mail.

Course Description

This is a 3-credit Ph.D. level course that provides a modern treatment of linear programming, network optimization, and integer programming. Special attention will be paid to the theoretical derivation of the simplex method and duality theory.

Course Pre-Requisites / Co-Requisites

You are expected to be thoroughly comfortable with undergraduate linear algebra, calculus and analysis, and basic proof techniques. Some familiarity with programming (python, Matlab, or C/C++) is also expected.

Course Objectives

- Understand fundamental concepts in optimization such as convexity, duality, complexity, etc.
- Understand and apply linear programming, including polyhedral theory, theorems of alternatives, simplex algorithm, duality, etc.
- Understand and apply large-scale linear programming models and algorithms, network models, and interior points methods.
- Model real-world decision problems mathematically and solve realistic-scale linear programs arising in various applications via Gurobi.

Materials and Supply Fees

No fees

Required Textbooks and Software

- ***Textbook****: Introduction to Linear Optimization*, by Dimitris Bertsimas and John N. Tsitsiklis, Athena Scientific 1997 (ISBN 10: 1886529191, ISBN 13: 9781886529199).
- ***Software****:* Python and Gurobi.

Additional references will be provided.

Course Schedule *(Subject to Change)*

Week	Date	Lecture Number	Topic
1	M 1/09	1	Course Introduction
	W 1/11	2	Linear Algebra Review
	F 1/13	3	Convex Optimization Basics (Chapter 1)
2	M 1/16		MLK Day – No Class
	W 1/18	4	Polyhedral Theory (Chapter 2): Concepts (HW1 Out)
	F 1/20	5	Polyhedral Theory (Chapter 2): Caratheodory's Theorem

3	M 1/23	6	Polyhedral Theory (Chapter 2): Radon's and Helly's Theorems
	W 1/25	7	Polyhedral Theory (Chapter 2): Equivalence of BFS, Extreme Point, and Vertex
	F 1/27	8	Polyhedral Theory (Chapter 2): Equivalence of BFS, Extreme Point, and Vertex
4	M 1/30	9	Polyhedral Theory (Chapter 2): Optimality of Extreme Points
	W 2/01	10	Polyhedral Theory (Chapter 2): Optimality of Extreme Points
	F 2/03	11	Polyhedral Theory (Chapter 2): Fourier-Motzkin
5	M 2/06	12	The Simplex Algorithm (Chapter 3): Optimality Conditions (HW1 Due, HW2 Out)
	W 2/08	13	The Simplex Algorithm (Chapter 3): Derivation of the Method
	F 2/10	14	The Simplex Algorithm (Chapter 3): Derivation of the Method
6	M 2/13	15	The Simplex Algorithm (Chapter 3): Implementation
	W 2/15	16	The Simplex Algorithm (Chapter 3): Gurobi
	F 2/17	17	The Simplex Algorithm (Chapter 3): Degeneracy + Bland's Rule
7	M 2/20	18	Duality (Chapter 4): Motivation (HW2 Due, HW3 Out)
	W 2/22	19	Duality (Chapter 4): Finding the Dual
	F 2/24	20	Duality (Chapter 4): Farkas Lemma
8	M 2/27	21	Duality (Chapter 4): Farkas Lemma
	W 3/01	22	Duality (Chapter 4): Duality Theory
	F 3/03	23	Duality (Chapter 4): Duality Theory
9	M 3/06	24	Duality (Chapter 4): Dual Simplex
	W 3/08	25	Duality (Chapter 4): Representation Theory
	F 3/10		Midterm
10	MWF		Spring Break – No class
11	M 3/20	26	Sensitivity Analysis (Chapter 5): Qualitative + Quantitative Analysis (HW3 Due, HW4 Out)
	W 3/22	27	Sensitivity Analysis (Chapter 5): Qualitative + Quantitative Analysis
	F 3/24	28	Large Scale Optimization (Chapter 6): Column Generation
12	M 3/27	29	Large Scale Optimization (Chapter 6): Column Generation
	W 3/29	30	Large Scale Optimization (Chapter 6): Danzig-Wolfe Decomposition
	F 3/31	31	Large Scale Optimization (Chapter 6): Bender's Decomposition
13	M 4/03	32	Network Problems (Chapter 7): Maximum Flow (HW4 Due, HW5 Out)
	W 4/05	33	Network Problems (Chapter 7): Shortest Path
	F 4/07	34	The Ellipsoid Method (Chapter 8)
14	M 4/10	35	The Ellipsoid Method (Chapter 8)
	W 4/12	36	Interior Point Methods (Chapter 9)
	F 4/14	37	Interior Point Methods (Chapter 9)

15	M 4/17	38	Integer Programming (Chapter 10): Modelling (HW5 Due)
	W 4/19	39	Integer Programming (Chapter 11): Complexity Theory
	F 4/21	40	Integer Programming (Chapter 11): Complexity Theory
16	M 4/24	41	Integer Programming (Chapter 11): Branch and Bound
	W 4/26	42	Integer Programming (Chapter 11): Cutting Planes
17	M 5/01		Final (10 am – 12 pm)

Attendance: Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Class Expectations: To ensure a classroom environment conducive to success for everyone, please turn off cell phones before class starts. Please make an effort to arrive at class on time. If you must enter the classroom late, be considerate and be as quiet as possible. Refrain from leaving early. If you need to do so, be as quiet as possible. Examples of a positive contribution to the class include asking questions that clarify any confusion you might be experiencing, constructively challenging the assumptions of a model, communicating your opinion about an open problem, or sharing your personal experience.

Homework: You are allowed to discuss problems with other students in the class, and you may refer to online resources, but you cannot share complete answers with each other. If you use any external resources (ideas from classmates, the internet, etc.), you must properly mention them at the start of your solution to each problem. You will *NOT* lose any points for telling the truth. All solutions should be written in LaTeX using the template available on Canvas.

Project: You are allowed to form groups with no more than three members for the project. Those who do not join any group need to finish the project alone. The project topics will be released by midterm.

Late Assignment Policy: All homework assignments are due on Mondays and should be submitted via Canvas before 4:55 pm. Late submissions will be deducted 10% for each additional day (submissions on Monday but later than 4:55 pm will also be counted as late for one day, and a 10% deduction will be applied).

Make-Up Policy: Make-up exams will be given only in case of UF-imposed curriculum requirement, religious holiday, jury duty, or a family/medical emergency. You must communicate with me as early as possible about the problem.

Evaluation of Grades

Assignment	Points	Percentage of Final Grade
Homework (5 sets)	100 each	20%
Project	100	20%
Midterm Exam	100	30%
Final Exam	100	30%
		100%

Grading Policy

The following is given as an example only.

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67

84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 77.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy
UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:
Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

COVID-19

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the UF Health Screen, Test & Protect website for more information.
- Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.